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ABSTRACT. The clinical condition and lung function of 14-year-old schoolchildren from three different districts of Budapest were recorded monthly between November 1972 and May 1973. R_{aw} and SG_{aw} values and lung volumes were measured and air pollution was recorded simultaneously. The latter differed significantly in the three districts. Although there were significant differences between the monthly lung function values and monthly air pollution, there was no evidence of any connection between the function values and environmental factors.

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Relationship between Lung Function Values and Air Pollution Data, in Budapest Schoolchildren *

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Abstract. The clinical condition and lung function of 14-year-old schoolchildren from three different districts of Budapest were recorded monthly between November 1972 and May 1973. R_{aw} and SG_{aw} values and lung volumes were measured and air pollution was recorded simultaneously. The latter differed significantly in the three districts. Although there were significant differences between the monthly lung function values and monthly air pollution, there was no evidence of any connection between the function values and environmental factors.

Key words: Schoolchildren — Environmental Factors — Lung Function Values.

The correlation between air pollution and respiratory diseases has become a very topical subject for study ever since the "smog catastrophe" in London in 1952 [29]. Many results have demonstrated a close correlation between air pollution and meteorological factors on the one hand, and respiratory complaints [8, 17, 20, 24, 36, 40, 43], respiratory morbidity [1, 3, 4, 9, 13, 16, 17, 20, 32, 41], mortality [3, 9, 20, 29] and respiratory function values [6, 15, 16, 17, 20, 28, 37, 38, 39, 43, 44] on the other particularly in young children, school-children, the elderly and in patients with chronic respiratory diseases [1, 3, 9, 13, 37, 40, 43, 44]. The causal role of smoking, social factors, the "urban factor" and respiratory infections in adolescence have also been emphasized in respect of the development of chronic bronchial diseases [5, 8, 10, 14, 22, 24, 35]. On the other hand, other authors have failed to demonstrate any such relationship with respiratory complaints [11, 15, 26] or respiratory function [2, 18, 23, 30, 33, 34].

In order to establish the short-term and long-term effects of air pollution and meteorological factors on the respiratory system, between November 1972 and May 1973 we carried out serial tests on 14-year-old schoolchildren in Budapest.

Material and Method

Three classes were selected from different parts of the city. The first school was in the centre of the city where air pollution and population density are at their greatest; the second was on the edge of an industrial area in the middle of a new housing estate, and the third school was in a non-industrialized suburb where the population density was fairly low (Fig. 1).

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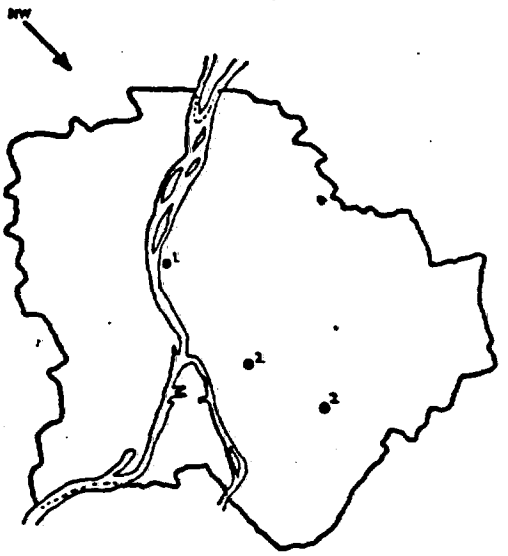

Fig. 1. The locality of the measuring stations and the schools. The population density in each district. Density of population: 1. = 23938, 2. = 8611, 3. = 2301; ● = air sampling station

The three classes (VIIIth class of the primary school) contained 86 children. These children were examined once a month from November to May, seven times in all. The Hungarian educational system is to send the children of each district to specific primary schools, and so the children are representative of the population of that district. Air pollution in the ivcinity of the schools was monitored throughout the period of the investigation.

Before the examinations, we prepared a questionnaire for each child in which we recorded previous diseases, school absences for respiratory ailments, details of home conditions and the parents' smoking habits and, possibly, those of the children. Each month the children were examined clinically and their lung function was tested.

For analysing lung function we used a volume-constant body plethysmograph (Bodytest, Jaeger Co., Würzburg). Intrathoracic gas volume (ITGV) and total airway resistance (R_{aw}) were determined by the plethysmography principle, and vital capacity (VC) from the integrated pneumotachygram. Total lung capacity (TC), residual volume (RV, RV·100/TC) and specific conductance values ($SG_{aw}=R_{aw}^{-1}\cdot ITGV^{-1}$) were calculated from the above parameters. Each month we also recorded the respiratory ailments, any respiratory disease and absences from school.

We measured the monthly mean readings for SO_2, NO_x and Cl_2 concentration and the amount of dustfall, and the daily readings for SO_2, NO_x and Cl_2 concentrations, and simultaneously recorded the meteorological parameters, outside temperature, humidity and barometric pressure. Monthly means for SO_2, NO_x and Cl_2 concentration were calculated from samples exposed for 20 minutes. Samples were collected eight to ten times a month at the same time at all measuring stations (between 11,0 a.m. and 2,0 p.m.). We used the pararosaniline method to determine the SO_2 concentration. NO_x concentrations were measured by the sulphanilic acid-alpha-naphthylamine method and Cl_2 concentrations by the Na-arsenite-silver nitrate method. The concentrations are stated in mg/m³. We measured dustfall continuously, and stated the dust levels in g/m²/month.

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The results were analysed statistically by variance analysis, variance analysis for two-way classification and by random block analysis.

Results

The expected correlation between the monthly means for SO_2 concentration and the seasonal or heating periods was in fact demonstrated. SO_2 concentrations varied in the districts studied, the highest levels being found in the middle of the city around the first school (mean monthly value being 0,91 mg/m³ in December) and the lowest levels in the suburb, around the third school (Fig. 2). There were no seasonal or local differences between NO_x and Cl_2 concentrations. The maximum mean monthly NO_x concentration was 0,19 mg/m³ and the Cl_2 concentration 0,36 mg/m³. There were very large fluctuations in the levels of dustfall in the vicinity of the first and second schools (maximum 37 and 38 g/m²/month, respectively). The fluctuations were not seasonal. There were fairly small fluctuations and low absolute readings in the vicinity of the third school, the maximum being 6 g/m²/month. Temperature and humidity showed the usual seasonal variations with a minimum temperature and maximum humidity in January (−0,7° C, 86%) and with the reverse maximum and minimum levels in May (+17,1° C, 55%).

Table 1 shows the children classified according to school and sex, with the corresponding Broca Index values. There was no significant difference between the Broca Index values for schoolchildren from the different schools (Table 1).

There was no significant difference between the ITGV, R_{aw} and SG_{aw} values for boys and girls. On average, vital capacity was about 400 ml higher in the boys than in girls in all classes. The mean R_{aw} values were higher than those reported in the literature for healthy adults [31].

We did not find any significant difference between the mean R_{aw} values in the three classes. These means were calculated from seven measurements. The results of

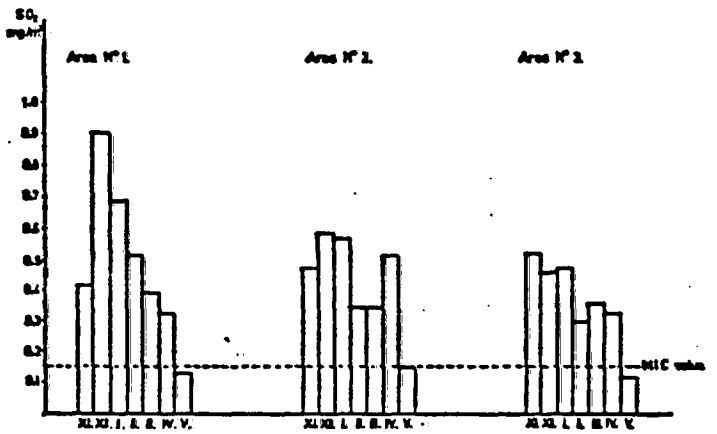

Fig. 2. The monthly means for SO_2 concentration (mg/m³) from November 1972 to May 1973 in the three measuring stations

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Table 1. The number of children in each class. Broca Index

	GIRLS	BOYS	TOTAL	BROCA INDEX
SCHOOL N° 1	18	12	30	80
SCHOOL N° 2	13	15	28	82
SCHOOL N° 3	15	13	28	80

Table 2. The monthly means for total airway resistance (R_{aw}) in the three classes fro November 1972 to May 1973. Statistical results. p values at the end of the lines show th results of variance analysis. p value below the mean annual values shows the level c significance between the three means

	NOV	DEC	JAN	FEBR	MARCH	APR	MAY	Mean annual values	p %
School N° 1	2.487	2.728	2.559	2.471	2.428	2.777	2.350	2.678	< 5
School N° 2	2.891	2.255	2.710	3.177	2.849	2.884	2.834	2.738	< 5
School N° 3	2.718	2.351	2.796	2.804	2.925	3.183	2.308	2.614	< 5
N° 1 - N° 2	p < 5	p < 5	p > 5	p < 5	p < 5	p > 5	p < 5	p > 5	
N° 1 - N° 3	p < 5	p > 5	p > 5	p > 5	p < 5	p > 5	p > 5		
N° 2 - N° 3	p > 5	p > 5	p > 5	p > 5	p > 5	p > 5	p < 5		

Table 3. Means for vital capacity (VC), residual volume (RV), total capacity (TC) and intrathoracic gas volume (ITGV) for each of the classes with monthly minima and maxima Statistical results

	SCHOOL N°1	p%	SCHOOL N°2	p%	SCHOOL N° 3	p%
VITAL CAPACITY (ml)	3386 [illegible]	< 5	3280 [illegible]	> 5	3568 [illegible]	< 5
RESIDUAL VOLUME (ml)	1405 [illegible]	< 5	1276 [illegible]	< 5	1361 [illegible]	< 5
TOTAL CAPACITY (ml)	4796 [illegible]	< 5	4541 [illegible]	> 5	4924 [illegible]	> 5
INTRATHORACIC GAS VOLUME (ml)	2588 [illegible]	< 5	2366 [illegible]	> 5	2635 [illegible]	> 5

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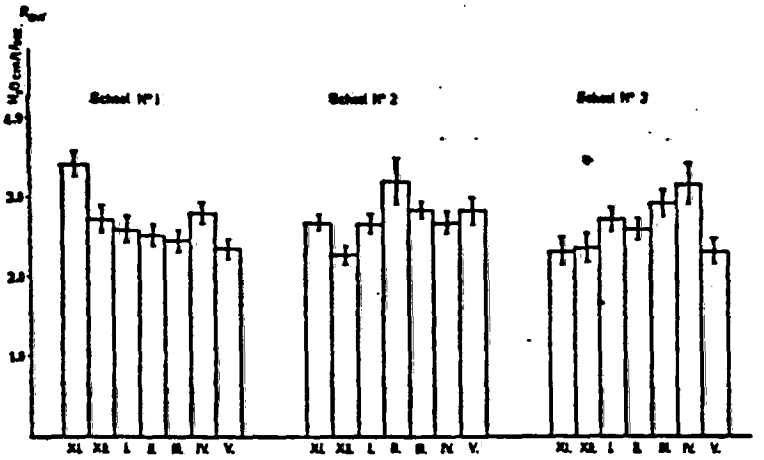

Fig. 3. The means for resistance to flow (R_{aw}) in the three classes from November 1972 to May 1973

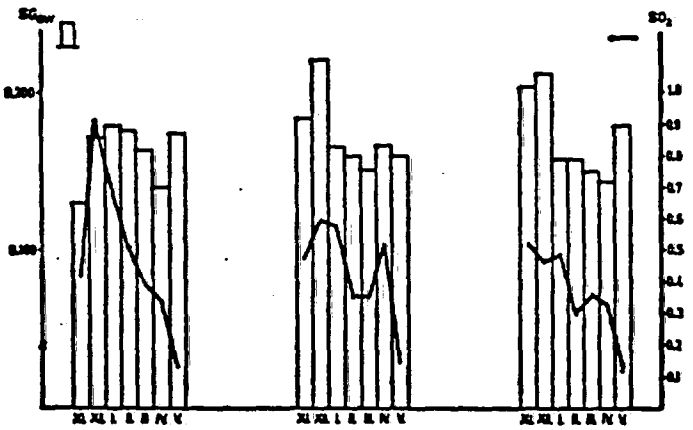

Fig. 4. The monthly means for SO_2 concentration in the three measuring stations and specific conductance (SG_{aw}) in the three classes from November 1972 to May 1973

variance analysis indicate that the mean R_{aw} readings for individual classes were statistically heterogeneous during the investigation. There were significant differences between the monthly means in all classes. These differences also appeared in individual months between the three classes (Table 2). However, although in two classes the R_{aw} values were actually lowest in May, there were no definite connections between season or locality and the SO_2 concentrations—air temperature and humidity values (Fig. 3). There were similar fluctuations of the SG_{aw} values (Fig. 4).

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Table 4. Statistical results of variance analysis for two-way classification of respiratory function parameters

		F	p%
VC	SCHOOL	12.62	<5
	MONTH	6.95	<5
ITGV	SCHOOL	15.69	<5
	MONTH	4.77	<5
TC	SCHOOL	11.65	<5
	MONTH	2.87	<5
RV	SCHOOL	3.76	<5
	MONTH	14.70	<5
R_{aw}	SCHOOL	8.78	>5
	MONTH	2.36	>5
SG_{aw}	SCHOOL	1.62	>5
	MONTH	4.84	<5

Table 5. Results of random block analysis of respiratory function parameters

		SCHOOL N° 1 n=17		SCHOOL N° 2 n=13		SCHOOL N° 3 n=21	
		F	p%	F	p%	F	p%
VC	children	32.35	<5	84.23	<5	72.40	<5
	month	45.54	<5	12.41	<5	22.67	<5
ITGV	children	11.38	<5	24.20	<5	28.01	<5
	month	4.86	<5	4.43	<5	8.12	<5
TC	children	15.95	<5	29.81	<5	39.76	<5
	month	9.23	<5	4.53	<5	1.50	>5
RV	children	3.84	<5	8.18	<5	5.89	<5
	month	4.58	<5	8.42	<5	10.30	<5
R_{aw}	children	8.78	<5	3.22	<5	8.17	<5
	month	8.77	<5	2.80	<5	4.38	<5
SG_{aw}	children	4.82	<5	3.33	<5	8.85	<5
	month	3.40	<5	4.60	<5	5.26	<5

There were significant differences between the monthly ITGV and spirometric means, but there was no evidence of a connection with environmental factors (Table 3).

There was no connection between the daily readings for environmental factors and lung function parameters. By performing variance analysis for two-way classification on the whole of the material, we demonstrated that the fluctuations in respiratory function values are affected more by seasonal factors than by locality factors. The two factors mentioned above do not have a significant effect on the scatter of R_{aw} values; the scatter of SG_{aw} values depends solely on time factors. These results demonstrate that the latter parameters of respiratory function are more stable (Table 4).

The results from the children who took part in all the investigations were evaluated by random block analysis. The numbers were 17, 13, and 21 in the first, se-

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cond and third class. The analysis verified that the significant differences were affected more by the variations in measurement results between individual children, than by the fluctuations in respect of time in the same children. These results also showed that R_{aw} and SG_{aw} values were the most stable (Table 5).

We did not find any connection between air pollution and respiratory complaints clinical condition and school absences caused by respiratory diseases. The latter was highest in February in all classes (coinciding with a mild influenza epidemic). Similarly, there was no connection between home conditions, smoking habits of the parents and respiratory function values.

Discussion

From the results we concluded that the respiratory function values, respiratory complaints and respiratory symptoms of healthy 14-year-old schoolchildren were neither affected permanently nor periodically by the prevailing level of air pollution. In our opinion, there is no permanent effect. This is based on the homogenity of the means for R_{aw} from the three classes. Since there is no definite correlation between air pollution levels as a function of time, and respiratory function values, we also doubt the short-term effect. It must be emphasized that the SO_2 concentration and meteorological conditions during the period of the survey did not show any extreme variations like those which occurred during the "smog catastrophe", although the SO_2 concentrations were far above normal, healthy standards. Presumably the significant fluctuations in the monthly means of some parameters were caused by other exogenous factors not studied as yet. Presumably also, the effects of environmental factors would be easier to detect in younger children or in the elderly and sick people. It is also possible that the methods we used are unsuitable for diagnosing very early changes in the peripheral airways. However, some of the more recent diagnostic techniques are still not completely satisfactory from the theoretical point of view, and we still know nothing about the importance of changes in the peripheral bronchi from the point of view of clinical prognosis [3, 5, 7, 12, 21, 25, 28, 42, 44]. We consider that, in view of the greater stability of the R_{aw} and SG_{aw} levels, these parameters should be suitable for serial studies. Thus, in our view, the effects of air pollution on the respiratory system have not been fully elucidated. The unanswered questions can only be answered by undertaking longitudinal and vertical studies on larger populations, using suitable methods.

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